Space Weather Technical Forecast

Issued on Sunday, 28 August 2022 at 01:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares (R1-R2; Minor-Moderate radio blackouts) Likely throughout. Chance of X-class flares. G1 Minor Storm possible with CME glance late day 1 or early day 2 (28th or 29th). Chance of S1 (Minor Radiation) Storm.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate, with the background X-ray trace at GOES16 residing at C-class levels. There were several M-class flares. These primarily came from AR3088 (Ekc/Beta-Gamma) in the far southwest which is approaching the limb. A long period M4.9 flare peaking 29/0240 UTC was observed from this large and relatively complex region, with a north-south aligned field. Previously a series of M-flares were accompanied with a sequence of CMEs off the southwest disc, however these have been assessed as either far-sided or missing. The CME related to the M4.9 flare also produced a fast CME, which has been assessed as giving a glancing impact late on the 28th or early 29th, although confidence is low due to limited SOHO imagery and the flare location.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was indicative of an ongoing coronal hole fast wind arrival. Solar winds started at slow-ambient levels 300-330km/s, with generally above average density, peaking at 35 ppcc at 27/1031UTC. The total interplanetary magnetic field (IMF), Bt, was at weak to moderate levels (8-14nT). The north-south component, Bz, was initially unremarkable, but became occasionally negative (southward) from 27/0900 UTC, reaching -12nT at 27/157 UTC. The phi angle was negative (towards the Sun) throughout. Geomagnetic activity was Quiet at first becoming, becoming Unsettled to Active by 27/1200 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV), as measured by GOES-16, rose from background levels from 27/0635 UTC to peak at S1, reaching 13.5 pfu at 27/1200 UTC, in response to the M4.9 flare emitted from AR3088. The high energy electron flux (greater than 2 MeV) was occasionally at High levels, with a peak of 1760pfu at 27/1315UTC but was generally at Normal Background to Moderate levels. The 24-hour integrated electron fluence started the period above the Active threshold (1e8 integrated pfu) with an increasingly downward trend, and 3.99e7 integrated pfu was observed at 2721000UTC.

Four-Day Space Weather Forecast Summary
Solar Activity: Further M-class flares are likely with a chance of an X-class flare. A gradual decline in solar activity is likely later in the period as AR3088 rotates off the southwest limb.

Solar Wind / Geomagnetic Activity: The aforementioned fast CME generated by AR3088 early on 27 Aug has the potential to give a glancing arrival late on the 28th or early 29th. Current coronal hole fast wind enhancement from CH18 is expected to give Active with a chance of G1 Minor Storm geomagnetic activity on day 1. Further enhancement into day 2 is likely from CH17, coupled with any CME arrival, and has the potential to give Active to G1/Minor Storms, with a

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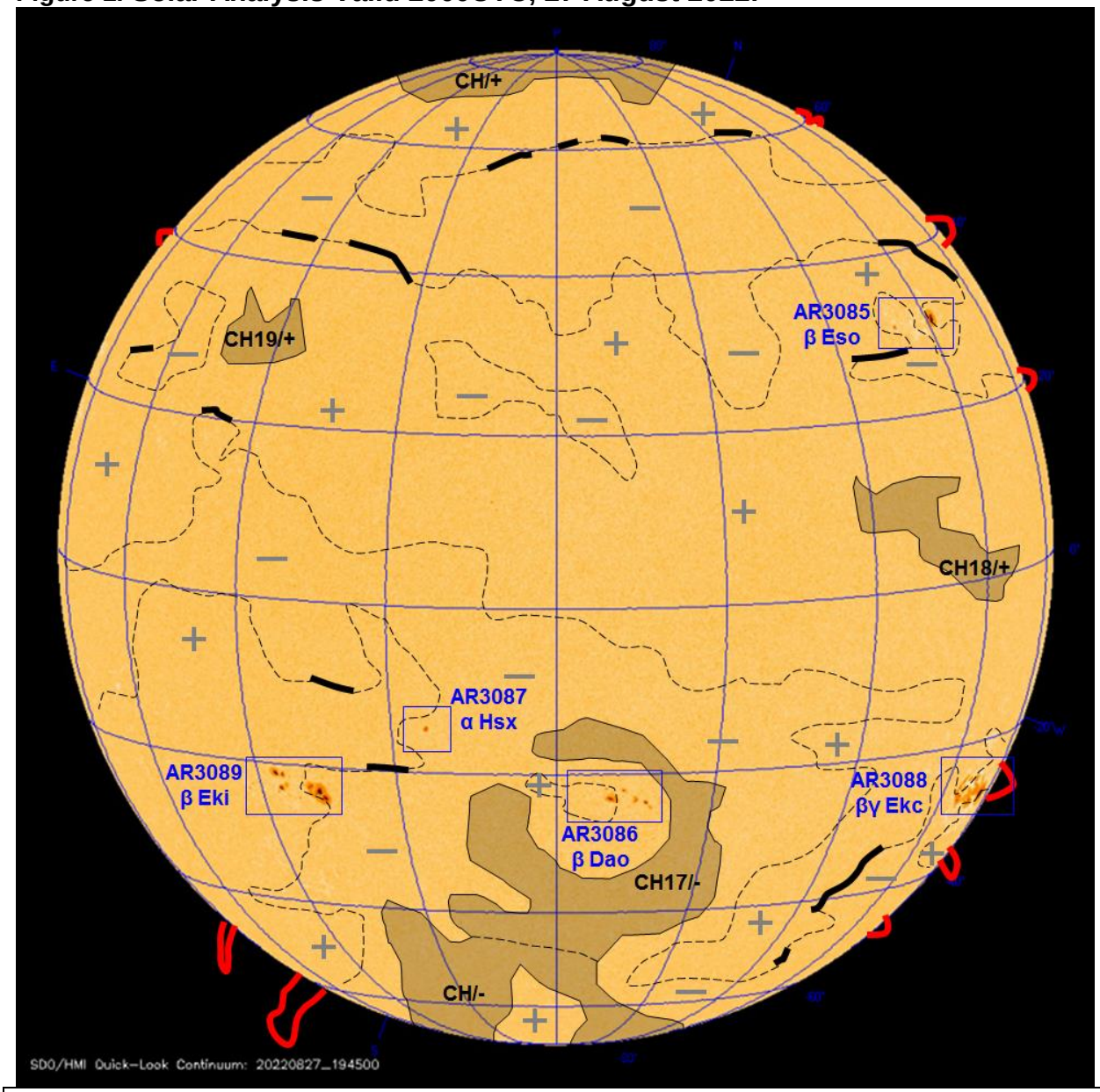
slight chance of G2/Moderate storms. Thereafter conditions are expected to ease towards background with increasingly Quiet geomagnetic activity.

Energetic Particles / Solar Radiation: High energy protons (greater than 10MeV) are currently just below the S1-storm level are expected to continue to erratically decline over the next few days, however further notable flaring from AR3088 has the potential to cause proton flux values to increase above this level. The high energy (greater than 2 MeV) electron flux forecast is low confidence, with any recovery of values on day 1 (28th) likely to see further decreases as any fast wind or CME arrival occurs. A recovery in values is likely thereafter, however this is low confidence at this stage. Current Active fluence is likely to remain below the active threshold and given the low confidence in the flux forecast, further Active fluence is currently uncertain, but most likely to occur later in the period.

Figure 1. Solar Analysis Valid 2000UTC, 27 August 2022.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The M4.9 flare of AR3088 that occurred early on the 27th, produced a fast CME travelling at 1250 km/s. This has been analysed as potentially having an Earth-directed component, giving a chance of a glancing impact, either late day 1 (28th) or on early day 2 (29th). There is some uncertainty however, due to the southern and westward location of the source eruption, giving the chance for the CME to miss, passing ahead of the Earth. Any Earth-sided CME associated with the M-flaring observed on the 26th is now expected to miss or be subsumed into this CME.
Earth is currently connected to the fast wind of positive polarity coronal hole 18. This is an immature feature, newly developed on this rotation, but has resulted in some moderately southward pointed IMF, likely due to the Russell-McPherron effect, where positive coronal holes are more geoeffective closer to the Autumn equinox. Due to this moderate southward IMF, Unsettled to Active intervals are expected with G1/minor storms possible on day 1 (28th).
A further fast wind arrival due to negative polarity CH17 is expected day 1, or possibly early day 2 (28th or 29th). This is a large feature in the southern hemisphere. With the potential for fast wind alongside a glancing CME arrival, there is an increasing chance for G1/Minor storm conditions during day 1 (28th) especially later or more likely during day 2 (29th), with G2/Moderate storm intervals possible. These conditions easing later day 2. Geomagnetic activity is then expected to trend towards Quiet with isolated Unsettled spells towards the end of the forecast period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	60	20	10
Strong	G3	No	5	10	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
27/0515	Partial	AR3088	SW	1250 km/s	29/0100 +-9h	Lo confidence. Glancing blow

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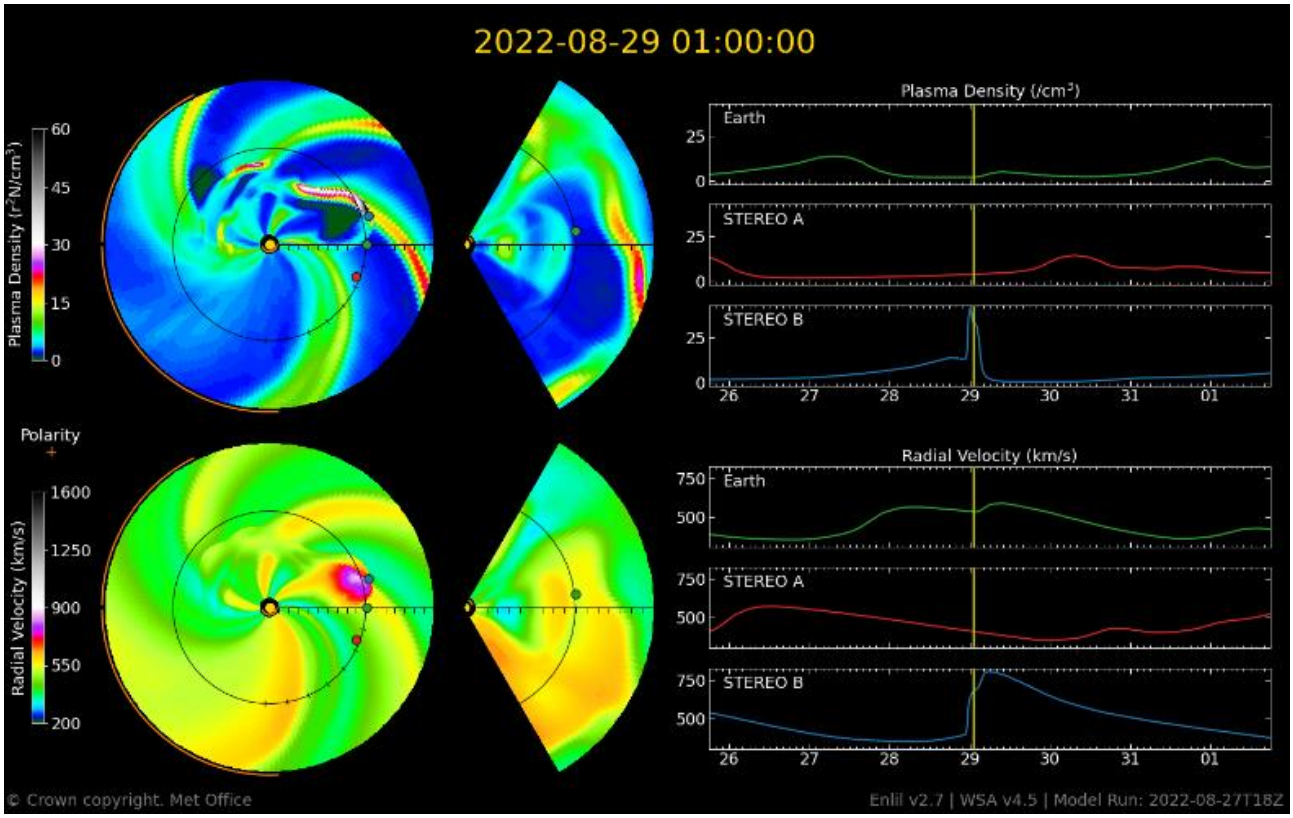
Figure 2: Met Office ENLIL output showing the CME reaching Earth around 28/0100UTC



Radio Blackouts - X-Ray Flares:

Solar Activity is Moderate with recent M-flares predominantly from AR3088 (Ekc/Beta-gamma) in the far southwest and approaching the limb. Further M-class flares are considered likely, with a slight chance of an isolated X-class flare, with the main risk again coming from AR3088.

The M-class flaring from AR3089 ended on 27 Aug due to a reduction in complexity of the region, with its spots spreading into a more standard bipolar configuration. However some development of the intermediate and trailing spots indicate there is potential for further future flares in the coming days as it progresses further west with time.

Conversely AR3088, peaking M4.9 27/0240 UTC, has continued to exhibit growth in areal extent despite its increasing viewing angle preventing a clear analysis. M-class flaring, coupled with dynamically evolving magnetic looping observed in SDO imagery, suggests ongoing complexity that may not be apparent from line-of-sight magnetograms. This is also supported by its north-south aligned magnetic field lines, suggesting potential for increased field line shear. This gives some notable uncertainty, but does suggest an increased chance for strong flares, given its size and history of flaring.

The other three regions on the disc, are generally smaller and simpler, with only a limited flare risk, however AR3086 in the south centre disc is of increasing interest and has shown some development of the intermediate spots and will need monitoring for further development.

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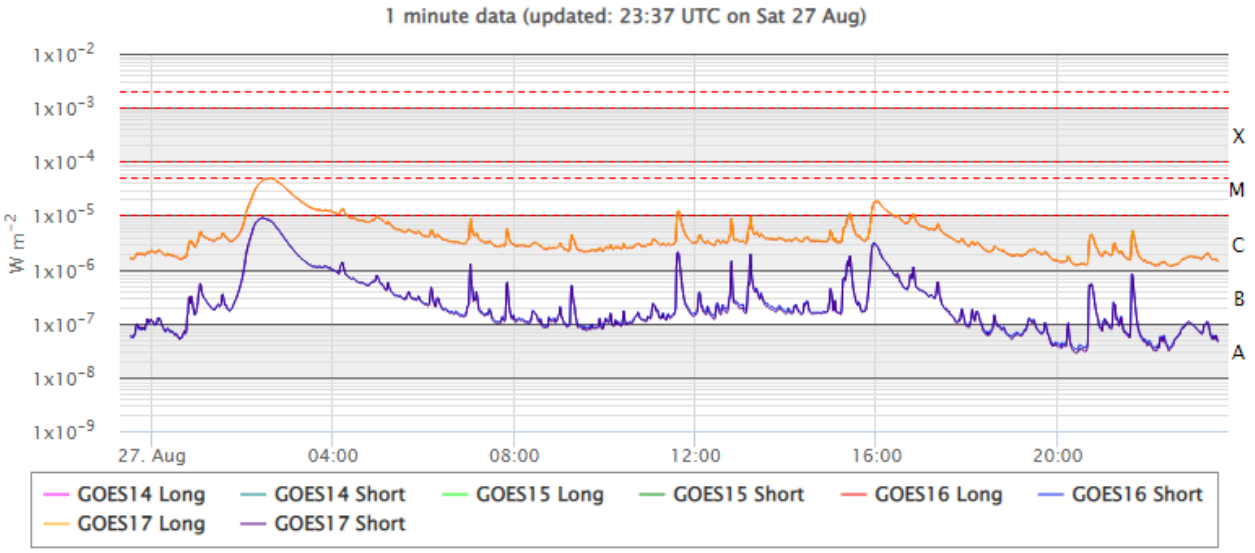
X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	60	30	30
Very Active	R3 to R5 X Class	No	25	20	5	5

Figure 3: GOES X-ray flux plot showing several M-class flares which oiginated from AR3088.



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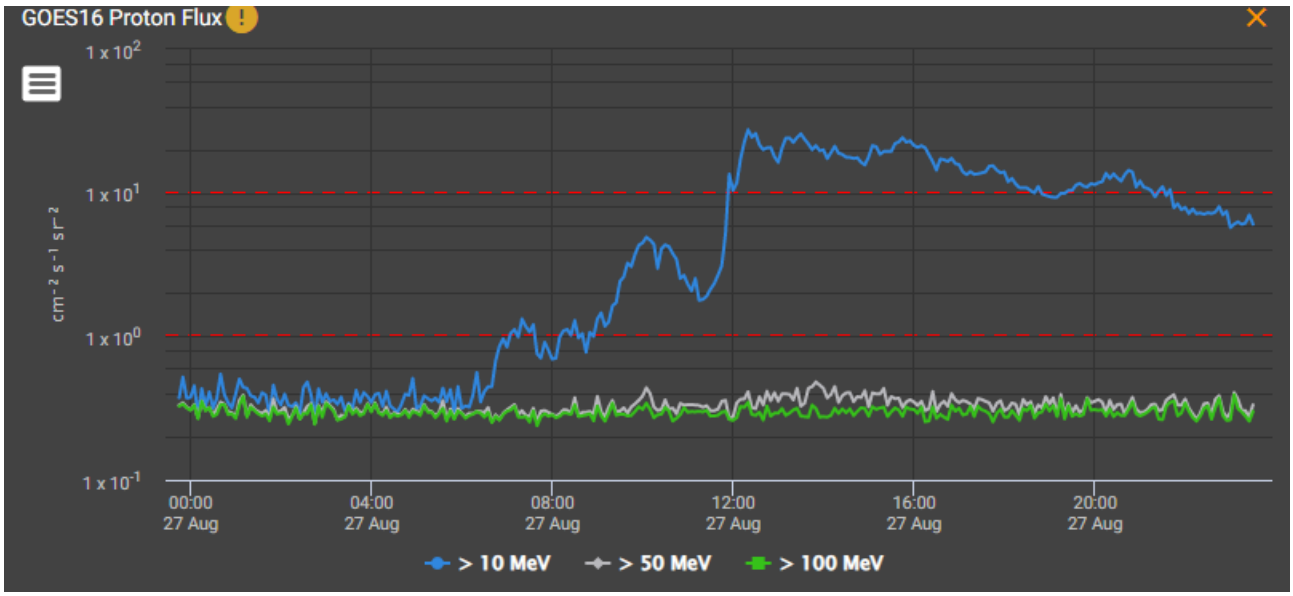
Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) has recently been enhanced by the long period M4.9 flare of AR3088, reaching above the S1 level with a 10MeV peak of 28pfu at 27/1220UTC. This shows the potential for any further significant flares from this particular active region to result in the occurrence of solar radiation storms, giving a chance of further S1 or greater through the coming days. This region is expected to rotate off the visible disc in the next 24 hours with a subsequent gradual and slight reduction in proton storm risk. Further active regions currently present on the Earth-facing Sun may also present a risk, especially AR3089. Otherwise, the proton flux is expected to only gradually and erratically decay back to background levels over the coming days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	25	25	20	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES 16 Proton Flux plot showing 10MeV activity exceeding the S1 threshold for a time.



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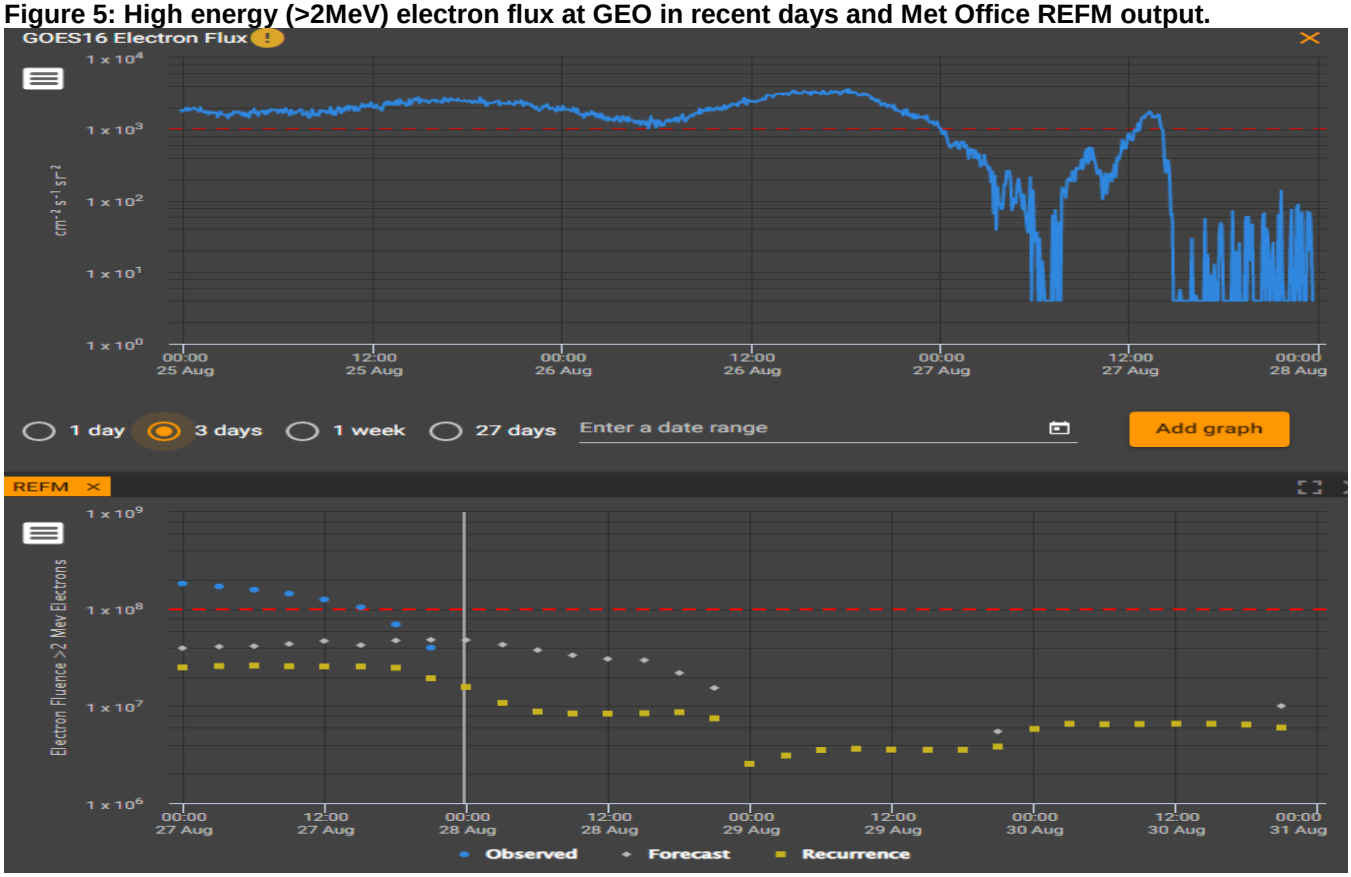
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as measured by GOES16, has been occasionally High throughout the last few days, but has declined to Normal Background to Moderate levels currently. This decline in activity due to the combined effect of increasing density ahead of the fast wind arrival from CH18, but also potentially related to the slightly increased proton flux due to the M4.9 flare from AR3088. Recovery to high levels is currently uncertain, but likely not to occur until ongoing geomagnetic activity from recent solar wind enhancement day 1 (27th) subsides. A potential CME glance, and also further fast wind arrival on day 1 (28th) into day 2 (29th), will again limit the recovery of flux values and increases uncertainty for the latter part of the period.

The associated 24 hour fluence is currently expected to remain below the Active threshold with a chance of rising again through the period, albeit with low confidence. This reduction is signaled by REFM, however given the potential enhancements to the solar wind that are expected which currently won't be accounted for by this model, this is likely to be of limited reliability.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	30	40	50	50
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: High energy (>2MeV) electron flux at GEO in recent days and Met Office REFM output.



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